Behavior of Southern Resident Killer Whales in the Presence of Vessels in San Juan Islands, Washington, USA

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Abstract

Southern Resident killer whales (SRKW) suffered a 20% population decline from 1996 to 2001. One of the potential risk factors to these whales is vessel disturbance. Focal follows of adult SRKW were conducted to assess behavioral responses to vessel presence. Swim speeds, respiration rates, dive durations (DD), surface durations (SD), surface active behaviors (SABs), number of vessels present within 1000 meters of the focal whale, and distances between the focal whale and nearest vessels were recorded. Preliminary results demonstrate no relationship between DD and the number of vessels present. Relationships between the number of vessels present and SD are complex and may differ between the sexes. In males, SD and the ratio between SD and the previous DD are nonlinearly related to the number of vessels present. Both decrease with increasing number of vessels but only when there are fewer than 15 vessels present within 1000 m of the whale. Furthermore, there is no relationship between the number of vessels present and the rate of SABs. However, the occurrence of SAB bouts may be related to vessel operation practices. In general, SABs occurred most often when the nearest vessel was transiting. The peak in SABs occurred when the nearest vessel transited within 100-225 m of whales. Fewer SABs occurred when the nearest vessel was stationary. These preliminary results suggest that vessels may cause short-term, minor changes in killer whale behavior. Further research, particularly in the fields of energetics and acoustics, is needed to fully understand the magnitude of vessel impacts.

Introduction

The Southern Resident killer whales (SRKW) that frequent the Puget Sound area, particularly near the San Juan Islands, suffered a 20% population decline from 1996 to 2001 (Krahn *et al.* 2002) and are now listed as "Endangered" under the U.S. Endangered Species Act. One of the potential risk factors to these whales is vessel disturbance. Southern Resident killer whales have been exposed to a greater number of commercial and private vessels in recent years, a trend that began before the commencement of the killer whale population decline. Whether these whales change their behavior(s) while in the presence of vessels is unknown. Other cetacean species demonstrate horizontal and/or vertical avoidance behavior in response to boats (Nowacek *et al.* 2001, Williams *et al.* 2002, Lusseau 2003, Ng and Leung 2003). Agonistic behaviors, such as slapping flukes or pectoral fins on the water's surface, may also be displayed (Williams *et al.* 2002). The objective of this study is to determine if adult Southern Resident killer whales demonstrate vertical avoidance (e.g., increase dive duration and/or decrease surface duration) or increase surface active behaviors (SABs; e.g., pec slap, tail slap, breach, spy hop) in response to vessels in the San Juan Islands during the summer whale watch season.

Fig. 1. San Juan Islands, WA, USA.

Fig. 2. Southern Resident killer whales near commercial whale watch boat off San Juan Island.

Methods

Study Location

Data collected from small research boat during the summer in the San Juan Islands, Washington, USA and southern Gulf Islands, British Columbia, Canada

Approach

Focal follows (15–60 min) of SRKW to collect behavioral and physiological data
Scan samples of killer whale groups and vessels to collect behavioral and compositional data

Study Subjects and Duration

2003: 3 week pilot study on adult males
2004-2006: 3-3.5 month study on adult males and females

Behavioral, Physiological, and Physical Data Collected:

Dive duration
Inter-dive surface duration
Surface duration : previous dive duration
[ratio corrects for longer surface intervals required after very long dives]
Respiration rate
Swim speed
Rates of surface active behaviors (SABs) *(see Fig. 7 for examples)*
Killer whale group information
[number of whales, spatial orientation (tight, loose, spread), arrangement (linear, non-linear, flank), generalized behavior state]
Location
[latitude and longitude]
Vessel Information
[number of each type (commercial, private, non-motorized) within 1000 m of focal whale, distances from research boat and nearest vessels to focal whale]

Data Collection Method

Fig. 3. Collecting behavioral and physiological data from an adult male SRKW using a customized Palm Pilot.

Results

Table 1. Summary of focal follows (FF) ≥ 15 minutes in duration (2003-2006)

Year	Adult ♀	Sprouting/Adult ♂	Total FF
2003	#FF: 0 ----------	#FF: 11 #Individuals: 3	11
2004	#FF: 11 #Individuals: 7	#FF: 33 #Individuals: 5	44
2005	#FF: 25 #Individuals: 19	#FF: 63 #Individuals: 7	88
2006	#FF: 48 #Individuals: 19	#FF: 80 #Individuals: 11	128
TOTAL	#FF: 84 #Individuals: 28	#FF: 187 #Individuals: 13	271

Table 2. Behaviors in relation to number of boats present within 1000 m (2003-2004)

Behavior	Significance
Swim Speed (m sec^{-1})	N.S.
Respiration Rate (breaths min^{-1})	N.S.
Total Number of SABs	N.S.
Rate of SABs (number hr^{-1})	N.S.
Average Surface Duration (sec)	Marginal Significance
Average Dive Duration (sec)	N.S.
Avg. Surface Dur. : Previous Dive Dur.	Marginal Significance

Surface and Dive Durations in Relation to Number of Boats Present within 1000 m

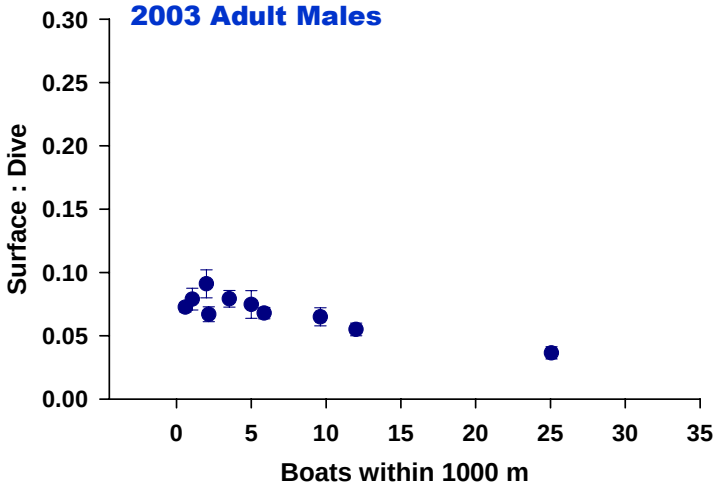


Fig. 4. Ratio of surface duration to previous dive duration in relation to the number of boats within 1000 m. Mean values for each focal follow of individual male SRKW in 2003 (n=10) are presented with ± 1 SE bars.

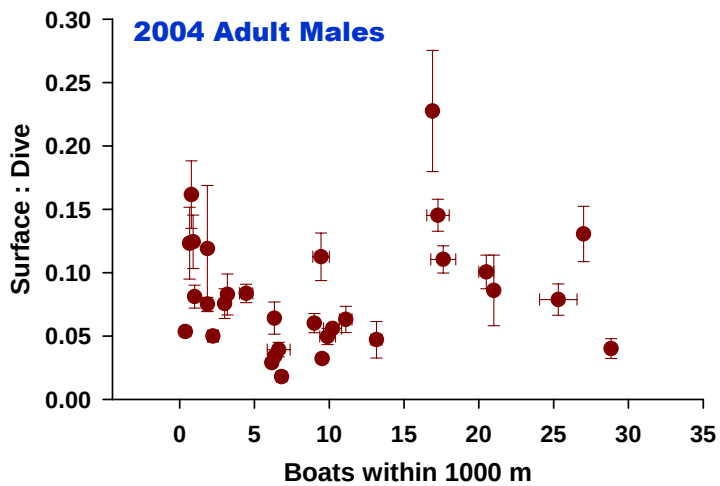


Fig. 5. Ratio of surface duration to previous dive duration in relation to the number of boats within 1000 m. Mean values for each focal follow of individual male SRKW in 2004 (n=31) are presented with ± 1 SE bars.

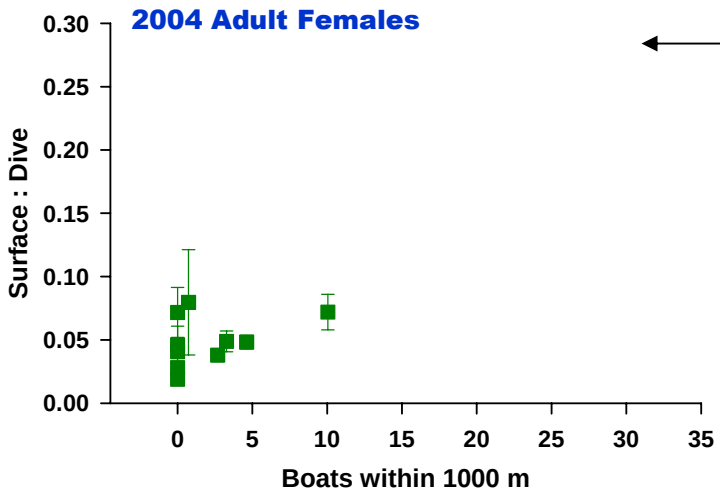


Fig. 6. Ratio of surface duration to previous dive duration in relation to the number of boats within 1000 m. Mean values for each focal follow of individual female SRKW in 2004 (n=10) are presented with ± 1 SE bars.

Focal Follows With Surface Active Behaviors

Fig. 7. Surface Active behaviors (SABs) demonstrated by Southern Resident killer whales off San Juan Island, WA: A) Tail slap, B) Spy hop, C) Breach.

2006 Adult Males and Females

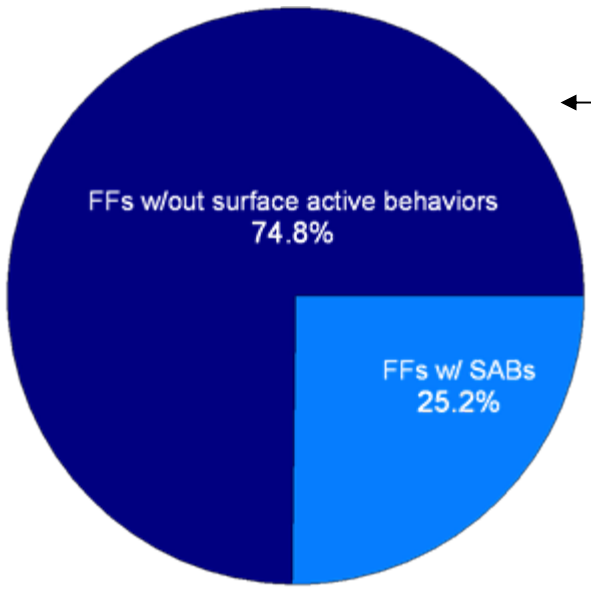
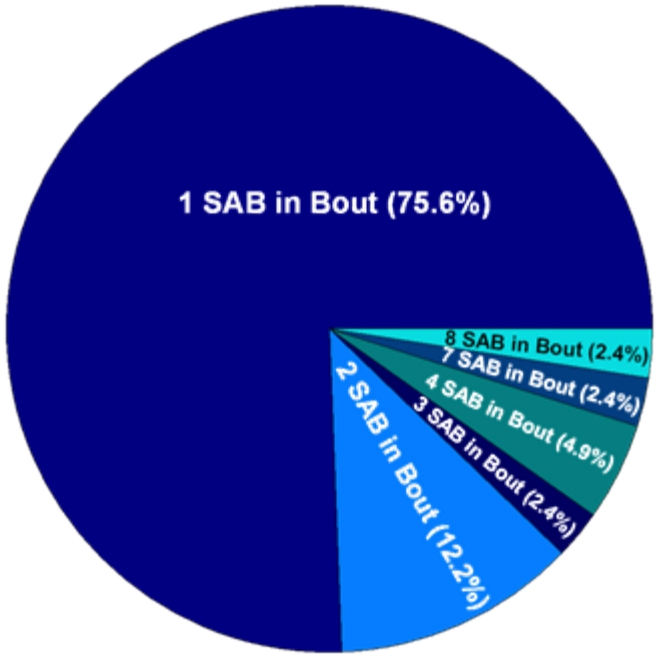


Fig. 8. Proportion of focal follows in 2006 during which at least one surface active behavior was performed by the focal Southern Resident killer whale.

Number of Surface Active Behaviors Per Bout

2006 Adult Males and Females

A) Nearest Vessel is Moving



B) Nearest Vessel is Stationary (includes idling)

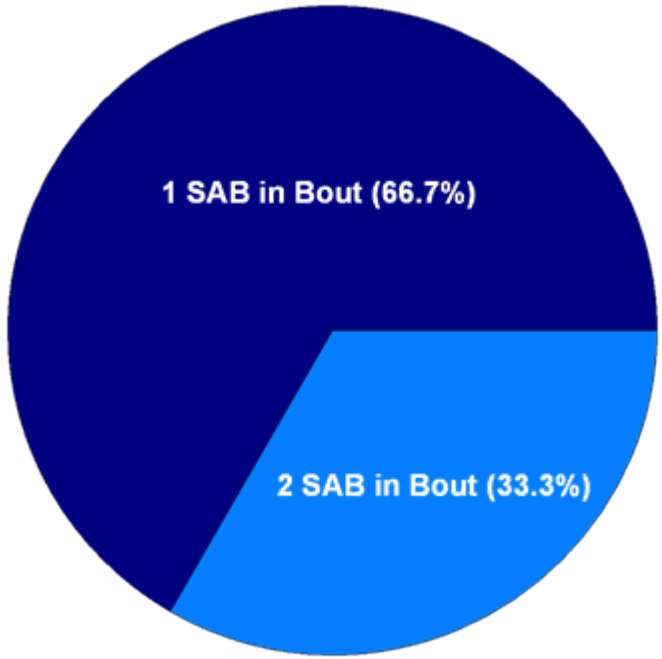


Fig. 9. Proportion of surface active behavior bouts that consist of 1 to 8 successive surface active behaviors (SABs) in 2006 when A) the nearest vessel is moving and B) the nearest vessel is stationary (includes idling). SABs often occur in bouts. Bouts are presented here to correct for the inflated numbers that result from presenting individual occurrences of each SAB. Individual SABs are lumped into one single bout when the time that passes between the performance of each successive SAB is 1 minute or less.

Occurrence of Surface Active Behaviors in Relation to the Distance and Operating Mode of the Nearest Vessel to the Killer Whale

2006 Adult Males and Females

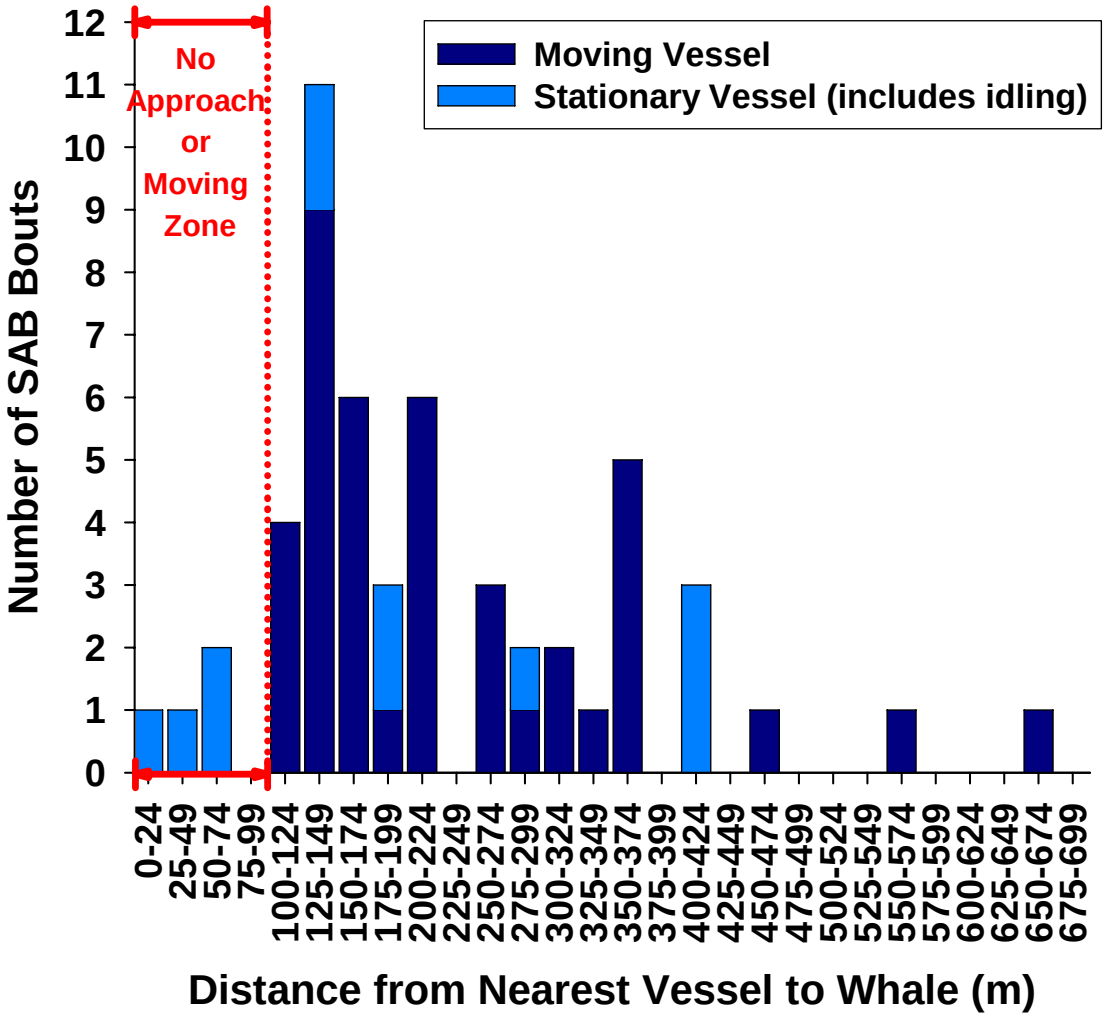


Fig. 10. Total number of surface active behavior (SAB) bouts for focal follows in 2006 in relation to the distance between the focal whale and the nearest vessel at the time the first SAB was performed. Distance data are presented in 25 m bins. Number of SAB bouts are presented in stacked bars with moving vessels designated by dark blue bars and stationary vessels designated by light blue bars. The distance from whales (0-100m) that is designated by "Be Whale Wise" Guidelines as an area that boats should not enter or move under power is shown in red.

Conclusions

- Focal follows provide detailed information to assess vessel disturbance in SRKW.
- Total number of vessels within 1000 m of SRKW have a slight effect on surface duration and the ratio of surface duration to previous dive duration in males.
  - Analyses of additional data are needed to assess whether the effect is the same when few (<15 vessels) and many (>15 vessels) are present.
  - Analyses of additional data are needed to assess the effect in females.
- SRKW only occasionally demonstrate SABs.
- The occurrence of SABs may be related to the mode of vessel operation in close proximity.
  - Most surface active behaviors occur when vessels approach SRKW to within 225 m, with a peak in SABs occurring at 125-149 m.
  - More SABs occur when the nearest vessel is moving rather than stationary.
  - These data suggest that SRKW may be affected by vessels moving within close proximity.
  - However, these results may also reflect the daily distribution of vessel operation modes in the vicinity of SRKW. Thus, additional analyses are needed to assess the complexities of the relationships between mode of vessel operation and SABs in SRKW.
- These preliminary results suggest that vessels may cause short-term minor changes in the behavior of SRKW.
  - Further research, particularly in the fields of acoustics and energetics, are needed to fully understand vessel impacts and their potential effects on the population dynamics of SRKW.

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